

Developments in Passenger Safety

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Passenger Restraint Systems***

Aircraft Seat Crashworthiness Standards Evolution

First Aircraft
Crash Studies

Civil Air Regulation
9g Standards

FAA Revised
Standards to 16g

First 16g A/C
Certification

1940's

1950's

1980's

1990's

- 75 to 80% of All Aviation Accidents Are Survivable
- Crashworthiness Standards Have Developed Slowly

Passenger Safety Standards Have Become More Stringent Over Past Decade

Why New Restraint Devices Now?

- **FAA Position on 16g Requirements**
 - **New Aircraft Certifications require compliance**
 - **16g Retrofit Rule Forthcoming for fleet**
- **Industry Reaction to 16g Requirements**
 - **Industry looking for solution to HIC at Bulkheads and Monuments**
 - **Current Means offer negative appeal**

The 16 g Crash Event



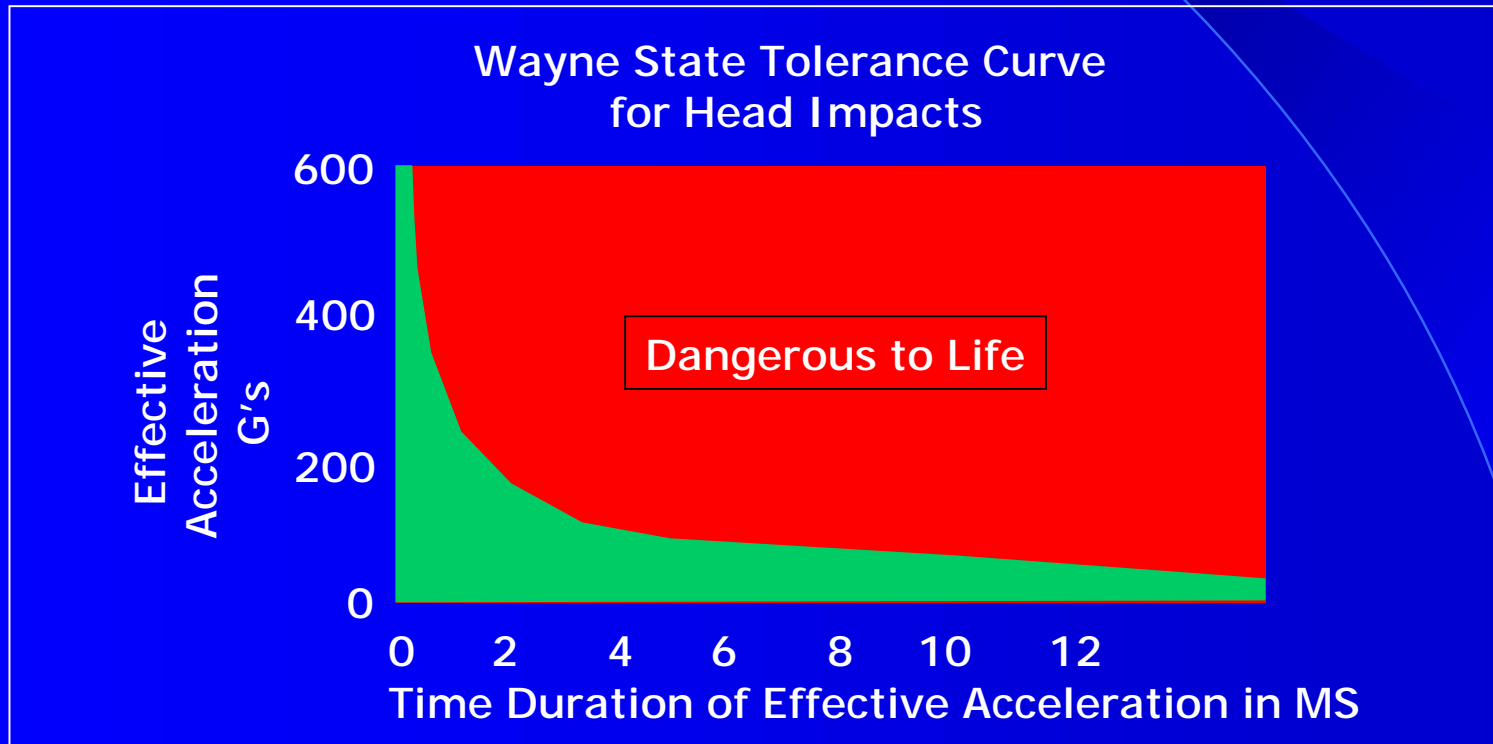
The 16 g Crash Event



Head Injury Criterion - HIC

$$HIC = \left[(t_2 - t_1) \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} a(t) dt \right]^{2.5} \right]_{MAX}$$

The Maximum Value of HIC is Limited to 1000



HIC Requirements Impact Airlines

- Increasing seat pitch reduces revenues
 - Airlines would lose thousands of seats in their fleet
- “Damping Devices” add weight and cost
 - Articulating seat pans
 - “Break-away” seat backs
 - Air bags
- Modified seat belts still require some amount of “setback” from hard points

Typical Wide Body Cabin Layout



Bulkhead Positions are Critical for HIC Compliance

7% - 10% of all Seat Positions

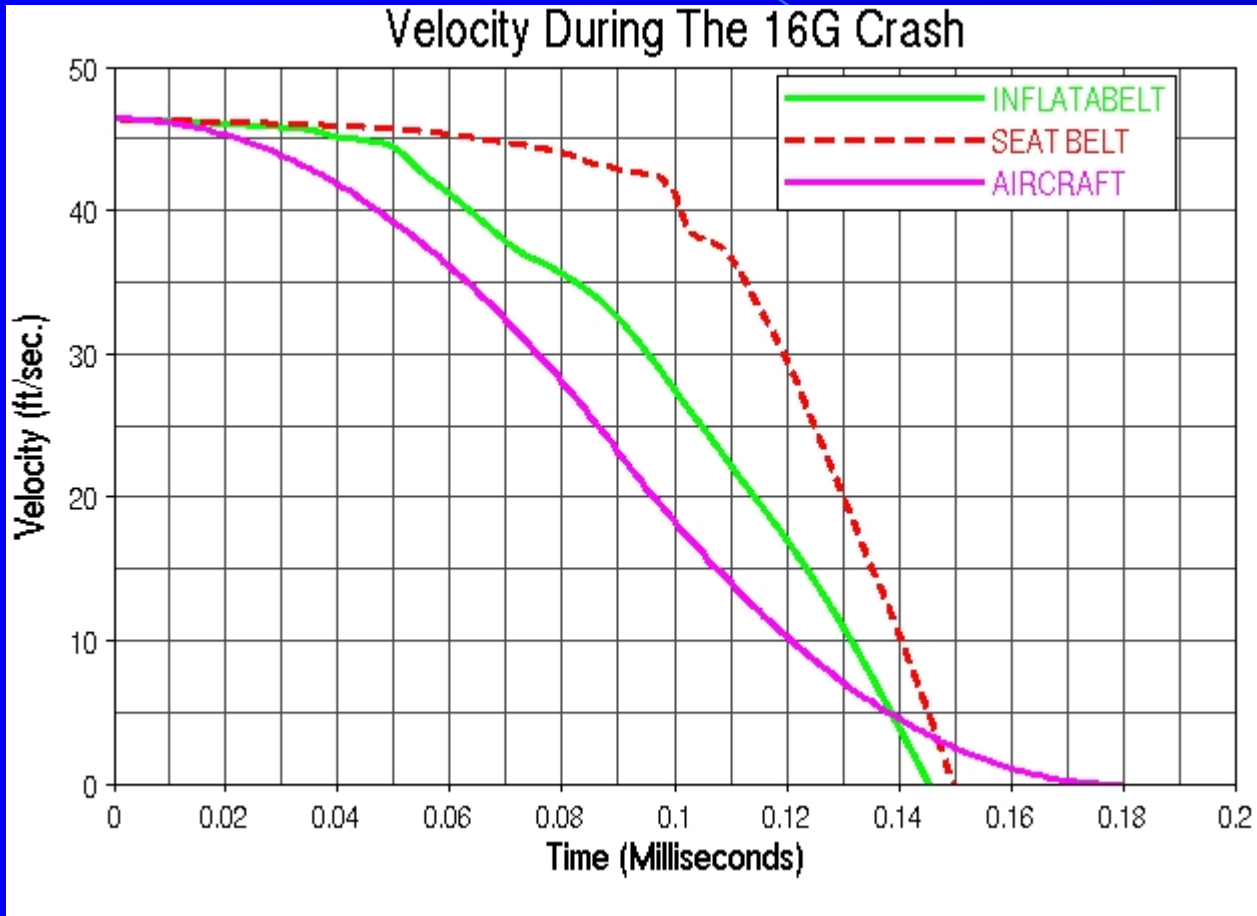
Inflatabelt™ Restraint System

- BFG Inflatabelt™ Transparent to Passenger
 - Appearance similar to current seat belts
- Goal: Universal Design, Attaches to Standard Belt Mount
- Integrated: Inflator/Self Powered Detector/Firing System

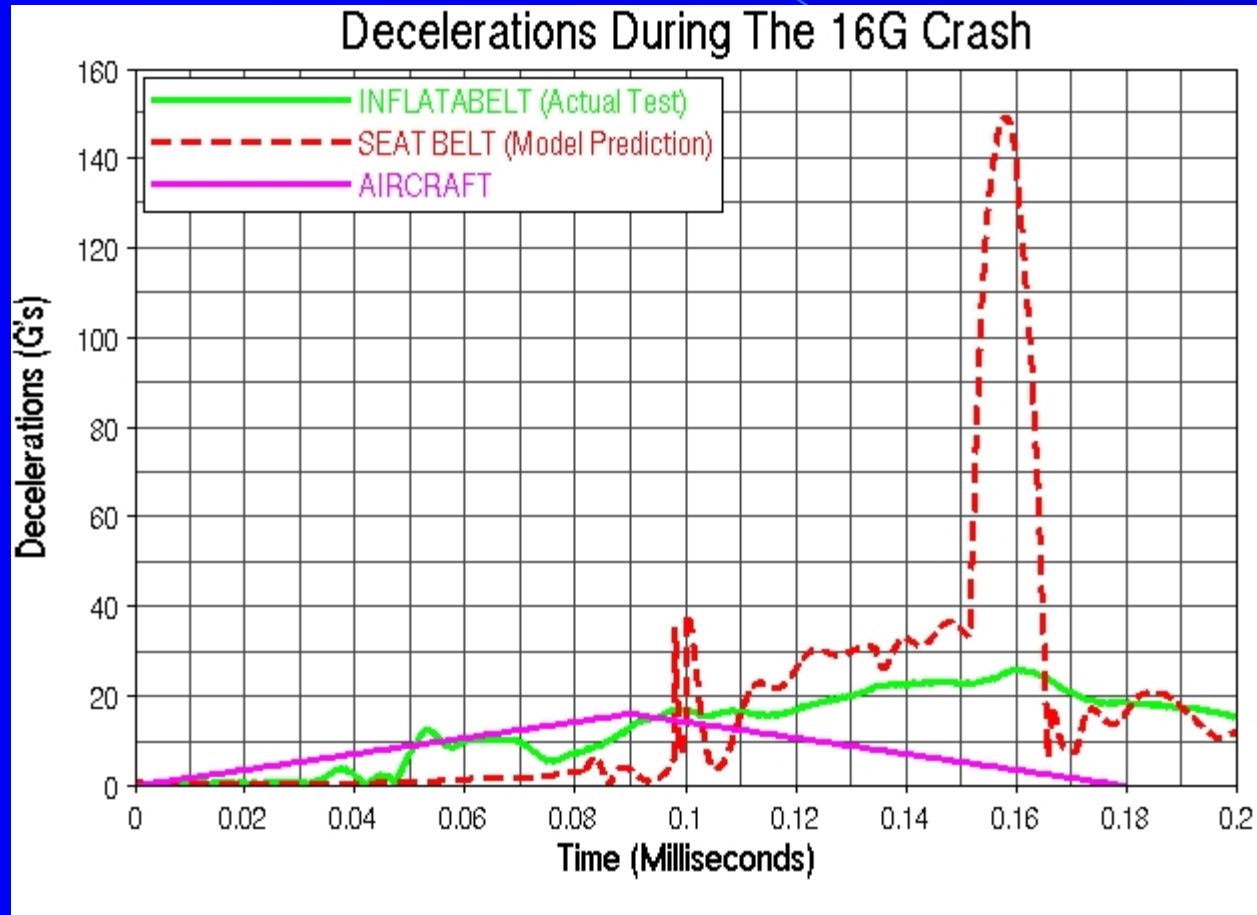
Inflatabelt™ Restraint System

- Design Philosophy
 - Inflatabelt™ Restraint System
 - Pretensioning
 - Load distribution
 - Energy absorption
 - Eliminate bulkhead contact

Head Velocity in the Crash



Head Deceleration in the Crash



Sequence Of Events



Non-Intrusive
Appearance



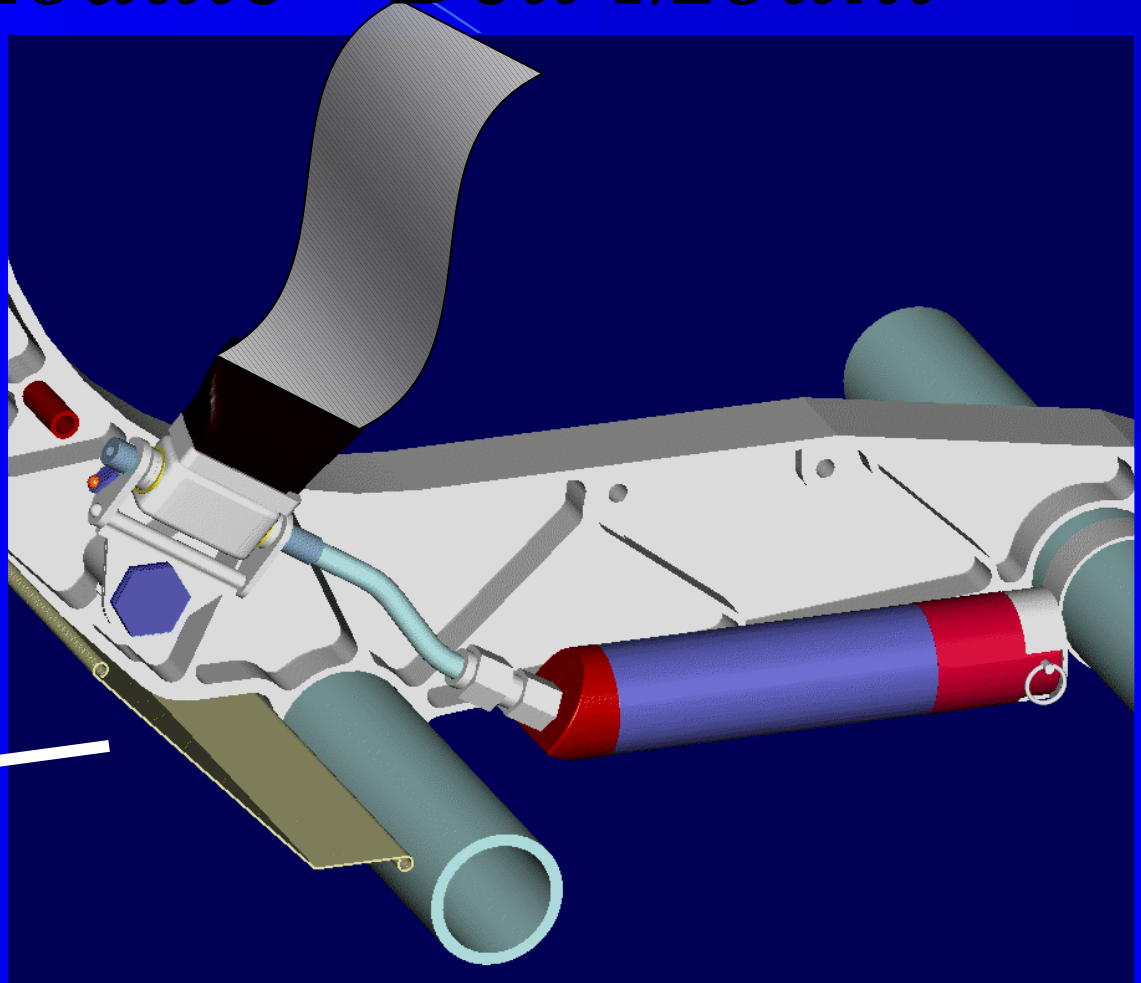
Deployment Pre-Tensions
Belt, Restricts Forward
Motion and Rotation
of Chest and Head



Deflates Rapidly to
Enable Egress

Actuation Module - Belt Mount

- Simple Tube Extension for Universal Mounting, Adapts to Seat Spreader
 - Inflator
 - Sensor
 - Anchor



Crash Sensor



- Battery Powered, No Aircraft Power Required
- Fires Inflator Very Early in Crash Event
- Is Not Activated When Exposed to Turbulence, Normal Vibration or RTO Thresholds

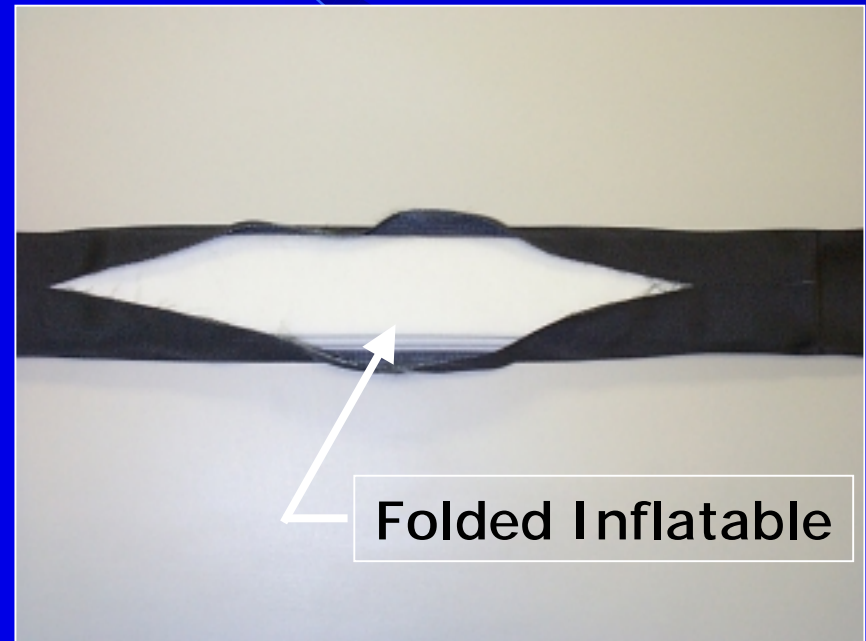
Direct Thermal Inflator , DTI™

- **Lowest Outlet Gas Temperature Inflator Available**
 - **Cool Gas Inflator - opens range of fabric choices**
- **Non-Toxic Inert Gas by Products - Argon, Nitrogen, CO₂**
- **DOT Class III Certified - Structurally Sound**
- **Small Size & Configuration Flexibility**



Deployment Module, Tubular Webbing

- Airbag Stowed Inside Seat Belt
- Inflatable Deploys from Tubular Webbing



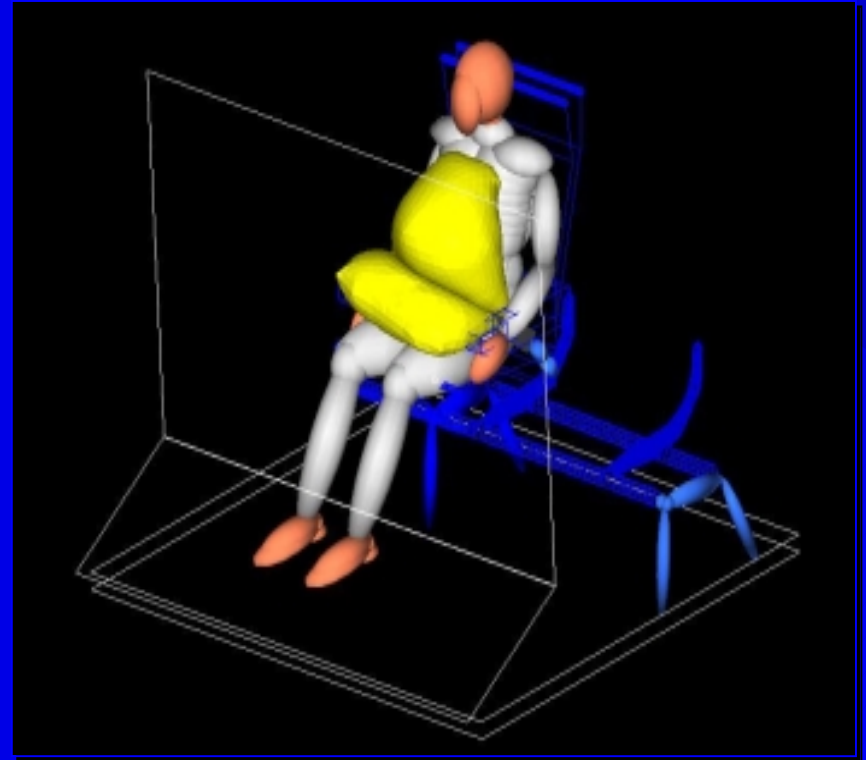
Deployment Module, Inflatable

- Polyurethane Coated Nylon
 - Lightweight/high modulus
- Air Retentive Fabric Meets Aircraft Flammability Requirements
- Good Packability/Low Belt Thickness

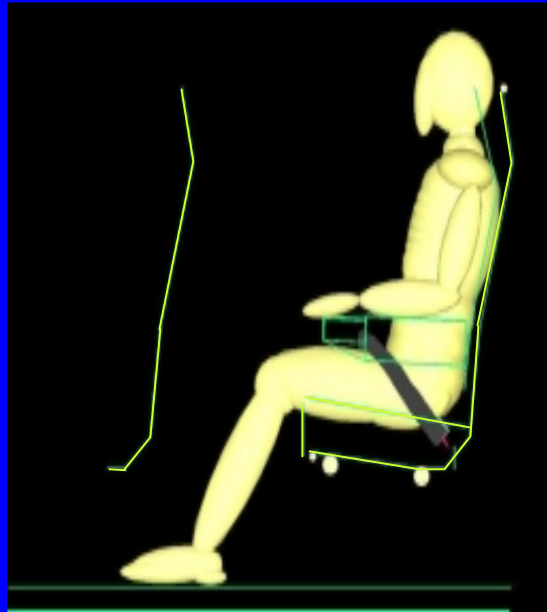


Development Approach

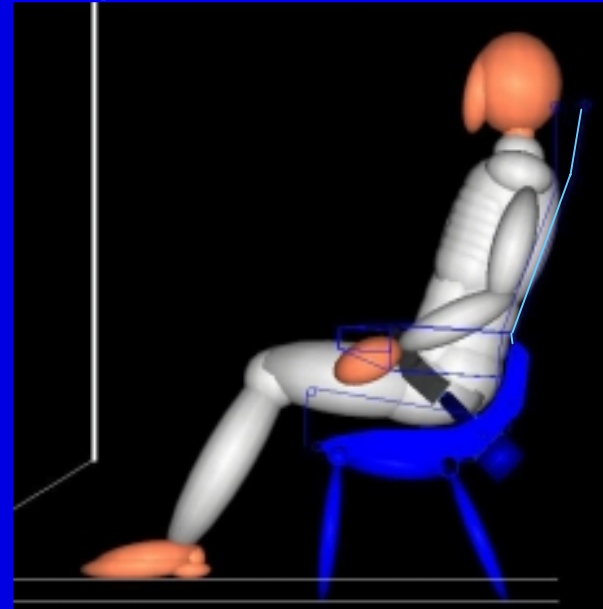
- Modeling Simulation
 - MADYMO - Mathematical Dynamic Model
 - Seat FEA
 - Full Occupant Kinematics
 - CFD Compatible (Thermodynamics)



Comparisons - Start



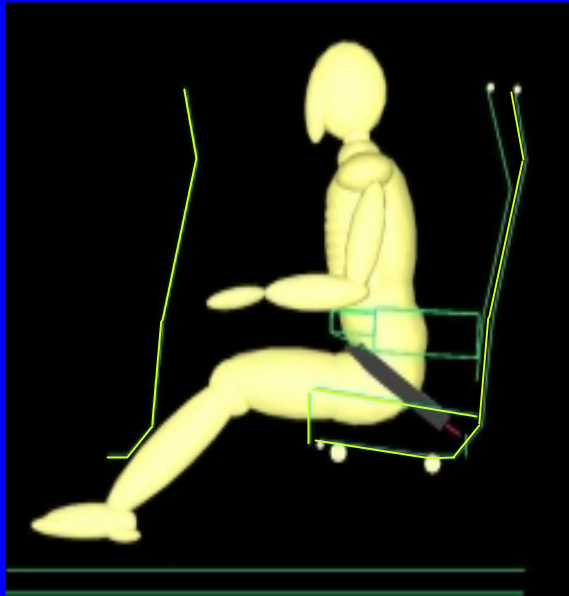
Standard Belt



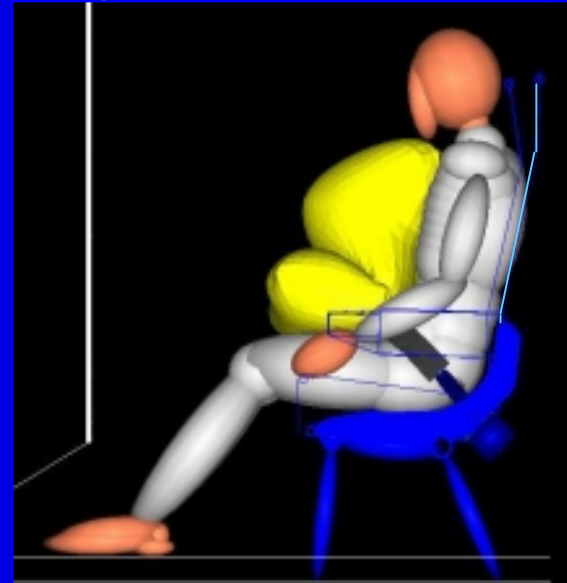
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Comparisons - Midpoint



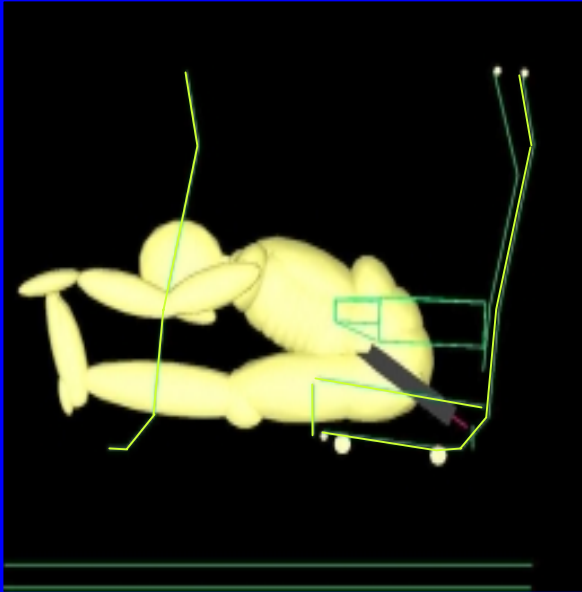
Standard Belt



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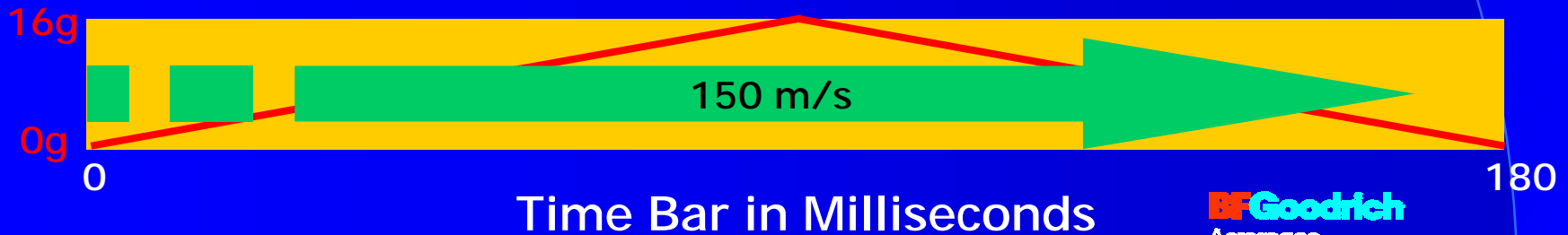
Comparisons - End



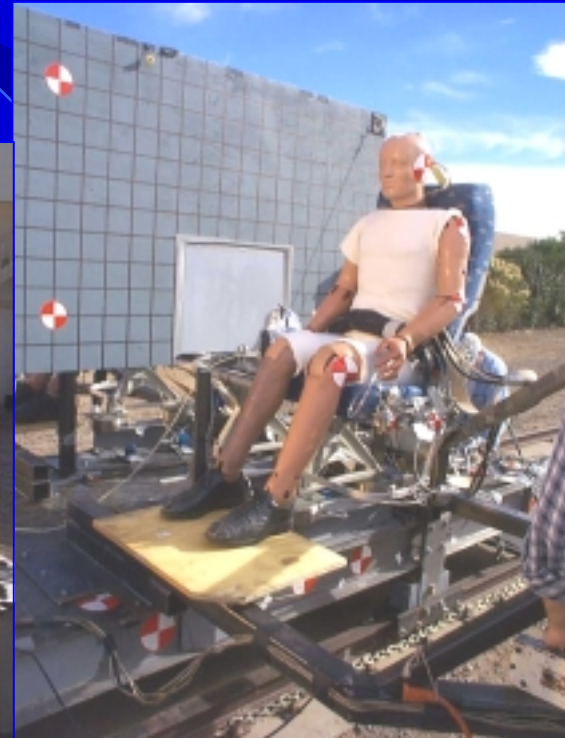
Standard Belt



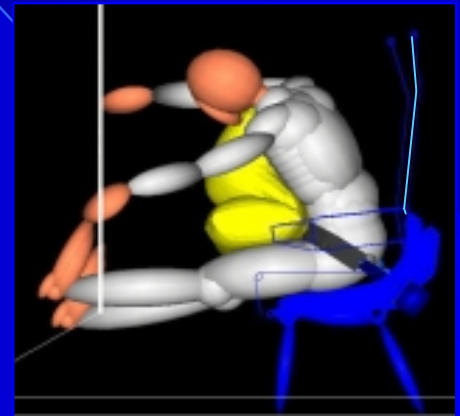
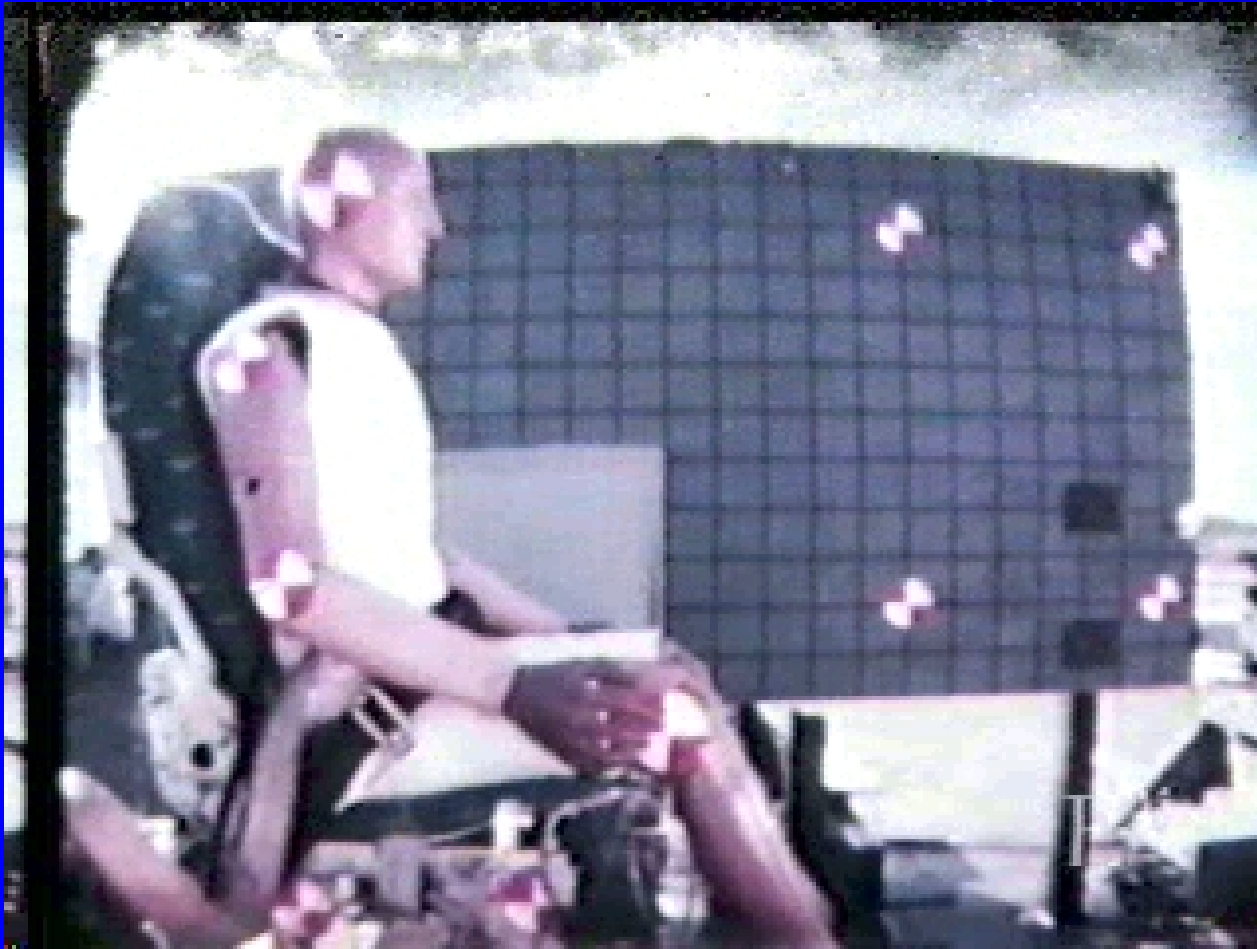
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Dynamic Test Facilities - Exponent



Inflatabelt™ Sled Test



Results of 12/19/98 Sled Test

<u>Method</u>	<u>HIC</u>
Sled Test Dummy	115
Model Prediction	105

Note: As There Was No Contact With Bulkhead or Aircraft Structure, HIC Would Be Zero By FAA Standards

Closing Remarks

Summary

- **FAA 16g Rule is Pacing Market**
- **Industry Poorly Prepared for 'HIC' Requirements**
- **BFG Has Excellent 'Technical Solution'**
- **Market Introduction Will Span 2 - 3 Years**